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Turbo-compressor

TEK-3200/3300/3400

RCM study

Client: PTTEP

Reported by Santi Songkunlertchai
Manorom Chiewpanich
Equity Services & Solutions Co., Ltd

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8.

1. Summary

The summary below indicates the major findings only.

1.1 It is found that the current job card is not full-fill the maintenance activities. Job card shall drilldown to activities and maintenance item level (sub-skid level) as per the result of this RCM.

1.2 Online washing should be introduced to Gas Producer in order to extend the crank wash interval.

1.3 To eliminate wax-gum cumulative at dry gas seal, the source of "buffer gas" shall be off-taken from the final discharge downstream of the after cooler.

1.4 Dry gas seal replacement interval shall be extended and based on "condition base" instead of "time base".

1.5 Online washing should be introduced to "compressor". Rigorous study shall be conducted to prevent "dry gas seal" damage during on-line wash.

1.6 Power augmentation should be introduced to gain the gas export.

1.7 Anti-surge function shall be tested-stimulated as regular basis.

1.8 To increase the system availability, "TT-3320" function should be changed from "shutdown" to "alarm" only.

1.9 Each compression string, it is found that the total maintenance cost with lost time for maintenance will be 76 million Baht per year

1.10 Each compression string, it is found that the minimum total production lost with out maintenance will be 487 million Baht per year, Maximum: 8000 million Baht per year

1.11 It can pointed that the average recovery time from breakdown should be 12 hours at the lost of revenue at 25% of each of gas compression string.

Cost from maintenance activities	76 231 593	Baht per year	with product lost (parts included)
Min production lost w/o maintenance	487 142 857	Baht per year	
Max breakdown cost with production lost	8 035 535 410	Baht per year	
RAM	2	A 0,5	

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2. Introduction

This report was made according the PTTEP Service Order No…….to conduct the RCM study using the combination of FMEA* (Failure Mode Effective Analysis) technique and FMECA* (Failure Mode Effective Critical Analysis*)

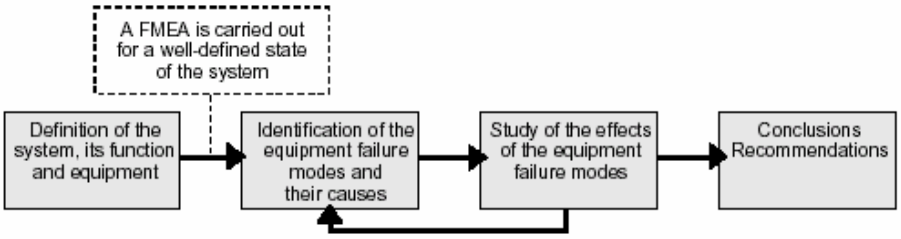
* Developed by Equity Services & Solutions Co., Ltd

Failure modes and effects analysis (FMEA)

FMEA is an analytical method to study the cause and effects likely to affect the equipment in an operating system in order to:

- assess the effects of each failure mode on the equipment in a system and on the various functions of the system
- identify the failure modes significantly affecting the reliability, availability, maintainability or safety of the system.

The main steps in the performance of an FMEA are illustrated



The FMEA methodology provides:

- Assurance that all conceivable failure modes and their effects on the system operation have been taken into account in the design or operation phase
- Identification of single failures, particularly where safety systems are generally designed to meet the single failure criterion
- An inventory of failure modes according to the extent of their effects on the system functions
- Identification of secondary failures and required redundancy
- Design of detection systems (for example, alarms, periodic tests) for the failure mode; the adequacy of these can be appraised
- Development of the appropriate maintenance procedure corresponding to each failure mode.

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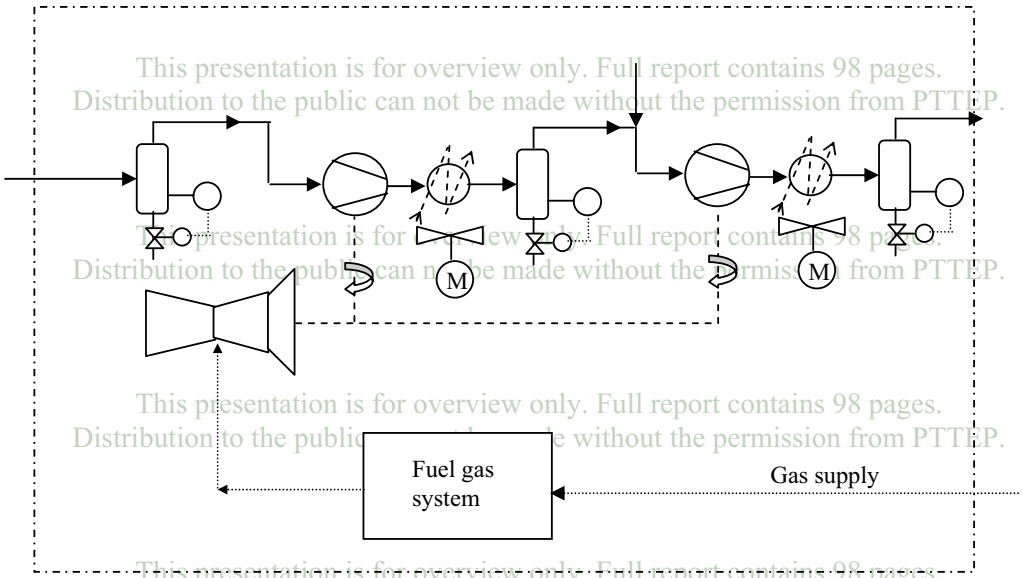
3. Work scope

The study cover the gas turbine driving export gas compressor for one unit only (three units are identical), and partly of fuel gas system (full scale RCM study of fuel gas system is separated) as per sketch.



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4. Details

4.1 This RCM study is based on:

4.1.1 MTTR (Mean Time To Repair) is not including the "lead time" of the work preparation or spare part.

4.1.2 Repair or replace process is based on spare module, assembly available e.g. starter, electric motor, gas producer module, etc.

4.1.3 On condition maintenance covers "on-line" and "off-line" and "occasion"

- On-line maintenance consists of all operating/process parameters, vibration analysis, oil analysis (RBOT), thermo-graphic, emission analysis, strain measurement, UTM, Pulse eddy current, and including visual external inspection.
- Off-line maintenance consists of all internal inspection, pressure test, geometric measurement, NDT, function test / calibration, Etc which requires to shutdown the system.
- Occasion maintenance is maintenance activity that schedule to be aligned with scheduled off-line maintenance.

4.1.4 Unplanned shows in RCM study as breakdown maintenance

4.1.5 Scheduled maintenance (either overhaul or replacement) interval is pre-fixed in master plan.

The firmed schedule maintenance will be based on the condition assessment which should be implemented 3-6 months ahead from the pre-fixed schedule using the projection/prediction technique.

4.1.6 **Operating context:**

Turbo-compressor function (TEK-3200/3300/3400)
All three compressors are installed at PP to deliver gas from separation process to Erawan platform as 33,3 % x 3 duty.
Custodian transfer is made at PP via flow-computer.

Operating condition
First stage Inlet parameter
Pressure, Barg : 23,1 (mean) max 24, min 23,0
Inlet temp, C : 24,4 (mean), max 25,6
MW 26,05 kg/kmol
Compressibility: 0,92 (inlet)
See gas compositions attached
Operating speed, rpm: 5900-6100 range

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First stage discharge
Pressure, barg: 56,3
Temp, C: 99,9

Second stage Inlet parameter
Pressure, Barg: 54, 1 (mean) max, min
Inlet temp, C: 50,8 (mean), max
MW: 26,05 kg/kmol
Compressibility: 0,865(inlet)
See gas compositions attached
Operating speed, rpm: 5900-6100 range

Second stage discharge
Pressure, barg: 108,2 (mean), 112 (max)
Temp, C: 119,8

Total Reliability and availability
Reliability: 99 %
Availability: 95 %

Each of gas compression train
Availability: 98,5 %
Reliability: unable to pinpoint due to insufficient information.

Delivery agreement, penalty
Guarantee point at delivery at 630 MMscfd (max)

Each compressor train comprise of:
LM-2500 gas turbine
PG-25 power turbine
NP: 2BCL-608, compressor, internal combine stage (1+2),

Lubrication system
GG uses synthetic oil: Mobil and TOTAL, VG-32
PG & comp used mineral oil: TOTAL VG-32

Seal system
Dry gas seal: John crane T28AT
Tandem arrangement
Buffer stage 1: Process gas
Buffer stage 2: Instrument air

LM-2500
Requires fuel gas: 7780kg/h (max) at 31 barg

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NP-2BCL-608

Each train, inlet gas before reaching gas compressor train has to be knock-out inlet liquid at suction scrubber.

After 1st stage compression: 99,9 deg C will be cooled by 1st air/gas cooler (A3230) to 52,4 deg C.

At 2nd stage, inlet stream will be combined with side stream at 54,1 Barg at 50,8 deg C. prior reaching 2nd comp unit, gas will be scrubbed by 2nd KO (D-3240)

Final outlet from 2nd compressor: 108 barg at 119 deg C will be cooled down via air / gas cooler (A3260) at 107,2 barg at 50 deg C.

4.1.7 Primary and secondary functions

As described, RCM is based on FMEA technique. Primary & secondary functions are determined from the above operating context as:

1	To deliver gas at 210 MMscfd at the operating condition
2	To meet availability 98,5%
3	To meet reliability 99%
4	To maintain lube oil/iquid containment
5	To maintain process gas containment
6	To limit discharge temp < 120 deg C at inlet 26 (1st) , 54 (2 nd st)
7	To maintain structural integrity
8	To maintain emergency response-life saving-asset integrity
9	To maintain the ignition integrity

4.1.8 Cost critical analysis is based on:

Operational capability	
Production capacity, MMscf/hour	8,75
Loss, of full capacity/hour	100%
Deferment, from loss of full capacity/hour	2%
Sale price, Baht/MMscfh	238 095,24

Rate, Baht/hour	
Specialist	3000
Elect	320
Helper	170
Instr	320
Mech	390
Prod	320
Tech-Elec	450
Tech-Instr	450
Tech-Mech	630
Welder	210

In addition, the total production loss of 28,013,400 million Baht is base on the penalty if no total-sale after 24 hours with the loss of sale opportunity of 5% interest

Parts and material cost is specified in each of failure mode individually.

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4.1.9 Risk Assessment

Risk assessment is quantified using the specific Risk Matrix and failure consequences which is developed to suit PTTEP business as:

Risk Assessment Matrix

				Production losses 25% A	50% B	75% C	100% D
Evident but no effects on HSE, environment of operation	Mild	72 h	1				
Evident degraded operation capacity, No effects on HSE		12 h	2				
Hidden degraded operation/non-operation capability, No effect on HSE		asap	3				
Evident safety and/or environment hazard Hidden safety and/or environment hazard	Lost of life	HSE	4				

Sample Coding 1B0.5

1	No effect to HSE
B	Cause production lost 50%
0,5	Probability occure 1 in every 2 years

4A0.25

4	Potential to lost of life or injure
A	Cause production lost 25%
0,25	Probability occure 1 in every 4 years

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4.1.10 Maintenance strategy

Maintenance strategy decision is based on the lowest quantified cost amongst tasks categories which the methodology is made differently as:

- "On Condition Maintenance (OCM)" has to be corporate with "Incipient failure" failure mode only.
  The cost of OCM is based on person(s) who carry out the On Condition Monitoring and assessment only.
  The subsequent "scheduled maintenance" cost is not considered on this maintenance task category.
  It is recommended that NON RECURRING MAINTENANCE & BUDGET should be reserved.

- "Scheduled Overhaul (SO)" will be carried out when it gives the lowest cost without effects to HSE
  The cost of SO is base on the total OCM cost (assuming equivalent to the total man-hour requirement for SO) plus spare parts divided by MTBF plus the cost of Loss & Deferment

- "Schedule Replacement (SR)" will be carried out when it gives the lowest cost without effects to HSE.
  The cost of SR is base on the total OCM cost (assuming equivalent to the total man-hour requirement for SR) plus equipment cost divided by MTBF plus the cost of Loss & Deferment divided by 3

- "Failure Finding (FF)" shall not corporate with "Incipient failure mode"
  The cost of FF is based on person(s) who carry out the FUNCTION TEST only.
  The subsequent "scheduled maintenance" cost is not considered on this maintenance task category
  It is recommended that NON RECURRING MAINTENANCE & BUDGET should be reserved.

- "Corrective Maintenance (CM)" will be carried out when it gives the lowest cost without effects to HSE
  The cost of CM is based on SO cost and further biased with the rejection value of the failure probability.

- "Redesign (RD)" will be commenced when all above are not applicable
  The cost of RD is based on the equipment cost divided by the useful life multiplied by 3

Component corrosion can be applied with this RCM as "Inspection" to be used as "FF"

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4.1.11 Failure Characteristic Analysis

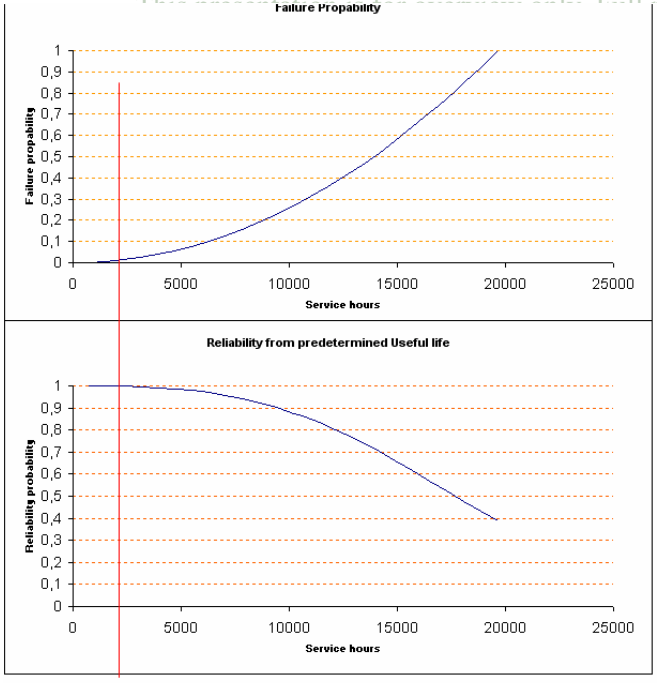
Each of failure modes is classified to the 1 of the six failure pattern shown.

Any failure mode that the history could be traced, the maintenance interval can be allocated naturally.

Any failure mode that history could not be traced, the failure pattern and predicted useful life and trouble free life and the potential to failure are model in Weibull curve as the function of:

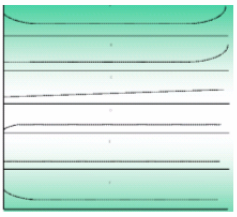
Weirbull probability density/distributions			**Probability of failure/rate**
Weirbull characteristic			failure rate = at^(b-1)
			a = scale factor/parameter
f(t) =(b/a^b)t^(b-1). Exp(-(t/a)^b			t = time in service
			b = weibull slope
b = shape parameter	6		
a = scale parameter	100		
t = start hour	50		

Failure rate R(T)=1/MTBF		or propability of failure
or		
$R(T) = at^{(B-1)}$		
a= scale factor	100	
B = Weibull slop, shape	6	
t =starting time in service	50	



FCA and Propability and Reliability model developed by Manorom C.(ESS Co.,Ltd)

Scale factor = 0,05
Slope parameter = 3
Starting time, hours = 750



pattern	slope
A	
B	>2
C	2
D	1-2
E	1
F	<1

Useful life, hours = 20000
Or MTBF as appropriate
Reject availability 98,00%

Notice. Time scale shall be aligned the "useful life /MTBF" by changing "scale factor" or "starting time"

Interval time should be half life of the reject availability or
800 hours FFI

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Figure 1

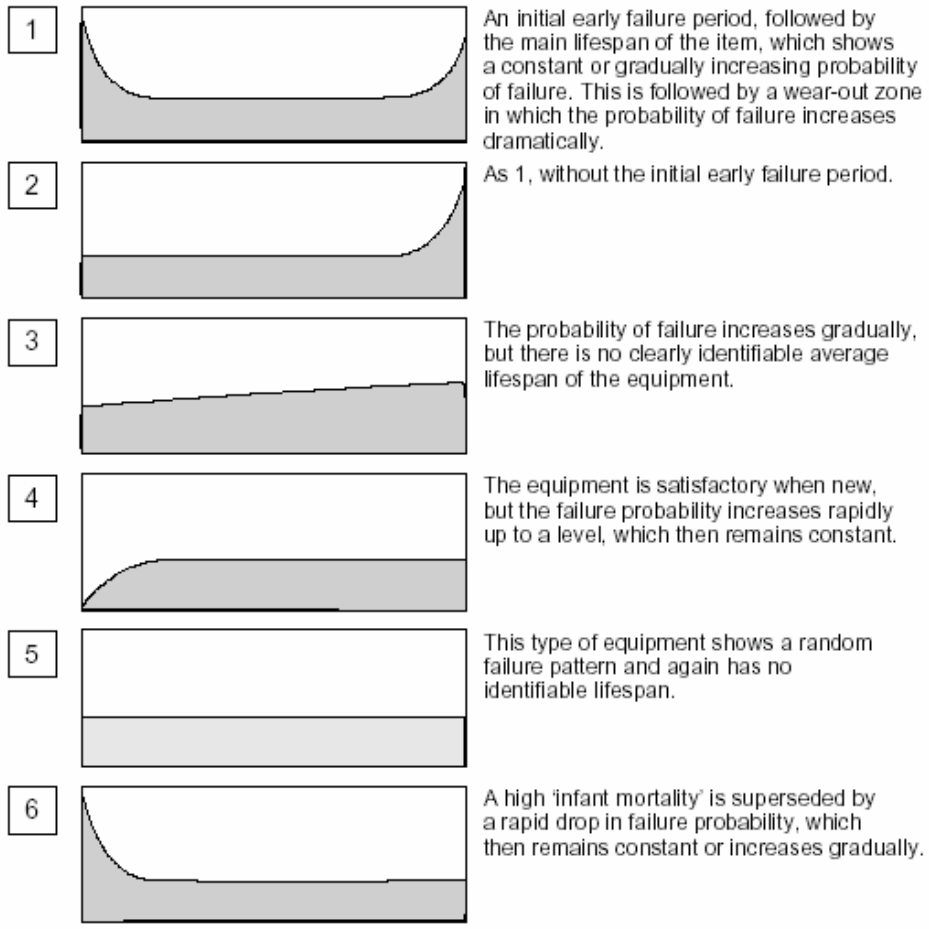

Figure 1: Six Patterns of Failure

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4.1.12 Function and failure mode

Primary/secondary function	
To deliver gas at 210 MMscfd at the operating condition	
Function failure	**Failure mode**
Gas compressor low performance	Fouling develop at compressor rotor
GG bearing failure due to lubrication degradation	Contaminates in synthetic oil degradation or oxidation.
GG blades fails from foreign object	High vibration due foreign objects to GG from corrosion on vane mist separator, air intake and exhaust ducts
GG low performance from	GG compressor blade fouling
GG unable to operated at desire speed/power	Inlet filter blockage
	TE3200 - High ambient temp, leads to low mass rate
	Fuel gas blockage (offskid)
	FV44220 Control VV, fails close due to controller malfunction
	XV42215 S/d/ VV, fails to stuck open or controller malfunction
	XV42225 fails to function, Loss of fuel gas supply from FV42220,
	TE3200 - Strainer (inlet fuel gas to GG) blockage
	XV42211 malfunction due to loss of instrument air
	LSHH42211 not activate or stuck
	SDV42200 malfunction
	PSV42210 passing
	T5 malfunction or spread due to thermocouples deteriorated
	XV42211 malfunction
	TE3200 - VSV control out of tolerances
	TE3200 - Corrosion cracks on compressor blades or blade coating damaged.
	PDSH42171 malfunction
	ARV42162 clogged up
	PSV42160 passing
	PSV42110 passing
	T42130 (oil/air separator) damaged or clogged up
	PDSL42713 & 15 malfunction
GG unable to start on demand due to starting system failed	TS3200 Gas starter failure
	TE3200 - Starting gas turbine regulating valve system malfunction

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Function failure	Failure mode
Insufficient cooling and lubricating GG, PT and compressor bearings.	A42145 & A 42820 - Cooling fan bearing failure.
	A42145 & A42820 - Transmission belt or pulleys failure.
Insufficient hydraulic oil supply to system	P42160 hydraulic pump failure
Insufficient lube oil to cool and lubricate GG, PT and compressor bearings.	A42145 & A42820 - Cooling fan failure.
Insufficient lube oil to cooling and lubricating compressor and power turbine bearings.	P42850 Filter blockage on discharge of cool down pump
	PDI42855 incorrect reading at low side
	TSH42823 malfunction
Insufficient lube oil to lubricate and cool GG, PT and compressor bearings.	M42820, 25 cooler fan motor bearing failure
Insufficient lube oil to lubricate and cool GG bearings.	TE3200 - P42110 synthetic oil pump failure
	TE3200 - P42140-43 Scavenge pumps failure
	PSV42246 passing
	TCV42147 malfunction
	A42145 & A42820 oil cooler fouling
Insufficient lube oil supply to cool and lubricate compressor bearings	M 42820, M 42825 bearing failure
	PCV42840 malfunction
	TV42821 malfunction
	M42850 bearing failure
	P42850 bearing failure
Insufficient lube oil supply to cool and lubricate compressor bearings.	M42805 bearing failure
	PCV42813 malfunction
Poor GG compression performance due to insufficient off-line cleaning on compressor blades	P42610, water wash pump failure
	M42610 bearing failure, water wash pump
	T42605 & T42600 tanks corroded or deposit in tanks.
	Deposits on H42605 heater or heater poor performance
PT or compressor bearing failure due to lubrication degradation	Contaminates in lube oil, mineral oil degradation or oxidation.
Unable to operate compressor on demand	XV3221 malfunction
Unable to operate compressor on demand due to high temp lube oil.	A42820 – Lube oil cooler fouling.
Unable to produce at the optimum point	FV3220 (1st stage anti-surge valve) malfunction
Unable to run compressor continuously due to both lube oil pumps not functioned.	PSL42812 not activated

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Failure mode	Local & System effect-1	Local & System effect-2	Local & System effect-3	Consequence and Category	Recovery, class	Severity class
P42805 - F42830 & F42835 filter blockage	Insufficient lube oil supply may cause high bearing temp trip.	However, PDSH42831 activated alarm, operator need to switch over standby filter.		C-Evident degraded operation capacity, No effects on HSE	2	A
PDSH 42831 not activated	No status on lube oil filter blockage is presented.	If not switch over to standby filter in a proper time, insufficient lube oil supply may cause high bearing temp trip.		E-Hidden degraded operation/non-operation capability, No effect on HSE	3	A
TE3200-M42500(AC) bearing failure	Low pressure alarm and activated standby ventilation fan running, in worse case possible high temp in enclosure room trip.	In case motor overload trip, standby fan will start automatically.		E-Hidden degraded operation/non-operation capability, No effect on HSE	3	A
TE3200-M42502 (DC) bearing failure.	If loss of AC power, insufficient ventilation for cooling in enclosure room when GG shutdown.	High temp in enclosure room may cause failure on instrumentation.		E-Hidden degraded operation/non-operation capability, No effect on HSE	3	No
TE3200-FDP42500 stuck closed	Low pressure alarm and activated standby ventilation fan running.			E-Hidden degraded operation/non-operation capability, No effect on HSE	3	No
TSHH42502 malfunction	Erratic signal may cause compressor trip.			E-Hidden degraded operation/non-operation capability, No effect on HSE	3	A
TE3200-FSL42500 malfunction	Improper ventilation fan operation can not be presented.	High temp in enclosure room can be presented alternatively.		E-Hidden degraded operation/non-operation capability, No effect on HSE	3	A
PDSHH42501 malfunction	If over activated fault, it cause GG erratic trip.			E-Hidden degraded operation/non-operation capability, No effect on HSE	3	A
PDSL42508 malfunction	When ventilation fan fault, no signal to start standby vent fan.	High temp in enclosure room may cause GG trip.		E-Hidden degraded operation/non-operation capability, No effect on HSE	3	A
TE3200-FDP42503 stuck closed	High pressure in enclosure room.	High temp in enclosure room may cause GG trip.		E-Hidden degraded operation/non-operation capability, No effect on HSE	3	A
TCP system malfunction	GG trip or can not start up			C-Evident degraded operation capacity, No effects on HSE	2	D
Blockage in primary or secondary DGS vent lines	Insufficient cooling on DGS face, heat up to cause DGS failure.	Compressor trip.		C-Evident degraded operation capacity, No effects on HSE	2	C

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Failure mode	Local & System effect-1	Local & System effect-2	Local & System effect-3	Consequence and Category	Recovery, class	Severity class
DGS failure due to deterioration buffer gas	Compressor trip.			C-Evident degraded operation capacity, No effects on HSE	2	D
Buffer fuel gas supply blockage due to strainer or check valve plugged.	PDSL 42710 activated alarm.	Dirt from process gas may pass to DGS and cause primary DGS failure.		E-Hidden degraded operation/non-operation capability, No effect on HSE	3	C
PDCV42710 malfunction	Operators have to open bypass valve immediately.	Dirt from process gas may pass to DGS and cause primary DGS failure.		E-Hidden degraded operation/non-operation capability, No effect on HSE	3	A
PCV42725 malfunction	Stuck open, PSH44725 activated alarm. Loss instrument air.	Stuck closed, buffer gas may leak to 2nd seal and gas contaminated lube oil.		E-Hidden degraded operation/non-operation capability, No effect on HSE	3	A
No instrument air supply to DGS due to orifice plate plugged	PDSL44713 & 14 activated alarm.	Stuck closed, buffer gas may leak to 2nd seal and gas contaminated lube oil.		C-Evident degraded operation capacity, No effects on HSE	2	A
PDT42710 malfunction	Improper control clean gas to against process gas leak to DGS			E-Hidden degraded operation/non-operation capability, No effect on HSE	3	A
PDSL42710 malfunction	If not activated when true, it may cause no immediate action to verify the problem.			E-Hidden degraded operation/non-operation capability, No effect on HSE	3	A
SDV3214 malfunction	If stuck closed, high liquid level (LAHH3211) may cause compressor trip.	If stuck open, LV3214 (automatic closed drain to 2nd stg separator) and closed drain header lines can be closed by manual valves.		E-Hidden degraded operation/non-operation capability, No effect on HSE	3	D
P42850 mech seal leakage	Lube oil spill to atm may cause fire.			B-Evident safety and/or environment hazard	4	A
LSL42801 malfunction	If stuck high and actual low level, it may cause lube oil pump run dry until motor trip.	If stuck low, during compressor startup sequences, main lube oil pump can not start due to impermissive from lube oil level fault.		E-Hidden degraded operation/non-operation capability, No effect on HSE	3	D
Igniter failure	No throughput due to unable to operate			E-Hidden degraded operation/non-operation capability, No effect on HSE	3	D
EI3222, EI3252 (discharge check valve) and station valve stuck opened	Back pressure may cause compressor rotor reversal turning.	Possible DGS damaged.		E-Hidden degraded operation/non-operation capability, No effect on HSE	3	A

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Failure mode	Local & System effect-1	Local & System effect-2	Local & System effect-3	Consequence and Category	Recovery, class	Severity class
PSH42844 not activated	Not signal to stop cool down pump, it may cause hot pump running if not stop by manual.			E-Hidden degraded operation/non-operation capability, No effect on HSE	3	No
TSHH 42502 malfunction	Possibly damage or burn instruments and controls.			E-Hidden degraded operation/non-operation capability, No effect on HSE	3	A

5. Maintainable item and interval and maintenance technique

Interval	On line Off line Occasion	Resource	Maintenance strategy	Work description	Tag
daily	On line	*Prod*	On condition maint	1) Since it is A/B/C/D arrangement, to monitor and switchover is normal practice. 2) While switchover, replacement filter is a must. 3) However, there are automatic control valves to open a bypass line across the filters when blockage.	Fuel filter skid
daily	On line	*Prod*	On condition maint	Walk around observe for noise & temp profile from passing	PSV-3210
daily	On line	*Prod*	On condition maint	Daily, verify that no passing leak of anti surge valve at normal operation	FV-3220
daily	On line	*Prod*	On condition maint	Daily check& record lube oil temp and pressure.	PSV 42246
monthly	On line	*Prod*	On condition maint	1) Monthly measure record fuel gas pressure	TE-3200 - Fuel gas strainer
daily	On line	Mech	On condition maint	1) Walk around to observe noise of icing from high gas flow 2) Visual check at valve stem position 3) Recommend to install work instruction at local.	XV-42211
daily	On line	Mech	On condition maint	Monitor & record lube oil pressure (PI42125) and temp (TE42121).	P-42110 PI-42125 TE-42121
daily	On line	Mech	On condition maint	Monitor & record oil sump temp and sump discharge pressure.	P-42140 P-42141 P-42242 P-42103
daily	On line	Mech	On condition maint	Monitor & trending diff. temp between TI 42144 and TI 42145.	A-42145 TI-42144 TI-42145
daily	On line	Mech	On condition maint	Monitor PDI 42170 and PI 42172 in order to verify hydraulic pump problem.	P-42160 PSV-42160 PDI-42170 PI-42172

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Interval	On line Off line Occasion	Resource	Maintenance strategy	Work description	Tag
4 years	***Occasion***	***Instr***	*Failure finding*	Clean, check calibration and function test on Occasion planned inherently with half life inspection.	LAHH-3241 LG-3243
4 years	***Occasion***	***Instr***	*Failure finding*	Occasion planned inherently with half life inspection, check calibration and function test.	SDV-3241 SDV-3242
4 years	***Occasion***	***Instr***	*Failure finding*	Occasion planned inherently with half life inspection, check calibration and function test.	FV-3250 FE-3250
4 years	***Occasion***	***Instr***	*Failure finding*	Occasion Check calibration and function test.	SDV-3211
4 years	***Occasion***	***Instr***	*Failure finding*	Occasion planned inherently with half life inspection, clean and check calibration.	FT-3200
4 years	***Occasion***	***Instr***	*Failure finding*	Occasion planned inherently with half life inspection, check calibration and function test.	PT-42842 PSL-42842 PAL-42842 PI-42842 PI-42841
4 years	***Occasion***	***Instr***	*Failure finding*	Occasion planned inherently with half life inspection, check calibration and function test.	PSL-42851
4 years	***Occasion***	***Instr***	*Failure finding*	Occasion planned inherently with half life inspection, check calibration and function test.	PSH-42831
4 years	***Occasion***	***Instr***	Scheduled overhaul	1) Operation inherent indicates the status 2) Occasion to lubricate the moving parts and function test	FDP-42500 FDP-42501 FDP-42502 SOV-42500 SOV-42501 SOV-42502
4 years	***Occasion***	***Instr***	*Failure finding*	Occasion planned inherently with half life inspection, check calibration and function test.	TSHH-42502 TSH-42501
4 years	***Occasion***	***Instr***	*Failure finding*	Occasion planned inherently with half life inspection, check calibration and function test.	FSL-42500 FSL-42501 FSL-42502
4 years	***Occasion***	***Instr***	*Failure finding*	Occasion planned inherently with half life inspection, check calibration and function test.	PDSH-42501 PDSHH-42502 PDSHH-42503
4 years	***Occasion***	***Instr***	*Failure finding*	1) Occasion planned inherently with half life inspection, check calibration and function test.	PDSL-42508 PDI-42507
4 years	***Occasion***	***Instr***	Scheduled overhaul	1) Occasion planned inherently with half life inspection, check calibration and function test. 2) Lubricate moving parts and function test	FDP-42503 FDP-42504 SOV-42503 SOV-42504
8 years	***Occasion***	***Instr***	On condition maint	Clean, disassemble to inspect and replace damaged parts Calibration test as required as standard RV certification.	PSV-3210
8 years	***Occasion***	***Instr***	Scheduled overhaul	Occasion planned inherently with half	PSV-42210

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Interval	On line Off line Occasion	Resource	Maintenance strategy	Work description	Tag
8 years	*Occasion*	Specialist	On condition maint	Occasion planned inherently with half life inspection; perform internal cleaning and inspection (RBI, check wall thickness and corrosion rate, etc.).	D-3210 D-3240
8 years	*Occasion*	Specialist	On condition maint	Visual inspection and clean if necessary	T-42800
8 years	Off line	Specialist	*Scheduled replacement*	Exchange GG , Inherently , inspect power turbine for life assessment	Gas generator
8 years	*Occasion*	GE	On condition maint	Life assessment during removing/exchange GG	Power turbine
10 years	Off line	*Instr*	*Redesign*	Redesign to alarm instead of shutdown	TT-3220 TI-3220
10 years	Off line	Specialist	*Redesign*	Redesign to relocate buffer gas off-take point to the final discharge line	DGS
10 years	Off line	Specialist	*Redesign*	Consider to cool inlet air temp or steam injection as power augmentation	Gas generator
10 years	Off line	Specialist	*Redesign*	Redesign online water wash to extend off line water wash interval	TE-3200
10 years	Off line	Specialist	*Redesign*	Redesign gas compressor on line washing using ZOC 27	K-3200-Compressor

6. Manpower and Resources

Estimated manpower and resources for each turbocompressor in loop of 8-10 years life cycle are as follows:

Turbocompressor (only one unit - TEK3200):	Avg. Man-hr/year (loop of 8-10 years life cycle)
Prod	255.5
Mech	1813.7
Elect	7.8
Instr	202.2
Specialist	173.2

Note: Manpower will be based on estimated effective work only (not included preparation, downtime and contingency works).
4 years interval will be turnaround period that may be extended to 5-6 years.

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7. Attachments

All information of Turbocompressor - RCM had been kept in a spread sheet (Excel file). Additionally concerned information also kept together in the same CD addressed to PTTEP accordingly.

- Drawings: PFD, P&ID
- Data Sheets: Gas Turbine & Compressor
- Drawings: Schematic Diagrams (LM2500 & NP compressor)
- Cross-sectional drawings: Gas turbine & Compressor
- Daily Log Sheets
- Lube Oil Analysis
- GT Compressor Cleaning